Original Article

Bacterial Contamination Study in Reusing Anesthetic Breathing Systems

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Background: Generally, a heat and moisture exchanger filter [HMEF] is being single used at the Y-piece of breathing systems. However, it is common to reuse the corrugated tubes for multiple patients in Thailand. Reusing corrugated tubes among patients could be a cause of bacterial contamination and cross infection. Therefore, sharing of the corrugated tubes and breathing systems is a concern amongst clinicians.

Objective: To evaluate the bacterial contamination and nosocomial pneumonia from using corrugated tubes on multiple patients.

Materials and Methods: This experimental observational study was performed with 30 corrugated tubes in each group and consisted of seven groups of corrugated tubes. Microbiological samples were obtained by swabbing at Y-piece every day. The corrugated tubes were also washed with normal saline, which was sent for bacterial culture. The corrugated tubes were changed according to seven different schedules at 24, 48, 72, 96, 120, 144, and 168 hours.

Results: One hundred sixty-eight breathing systems comprising of 891 microbiological samples from both Y-piece and corrugated tubes were tested for bacterial contamination. The Chi-square test and McNemar's test revealed no statistical significant differences among those groups in bacterial contamination and transmission of nosocomial pneumonia ($p<0.001$).

Conclusion: The long-term use and sharing of corrugated tubes during 24 hours with single used of HMEF at the Y-piece of breathing systems did not increase significantly the risk of bacterial contamination and infection. For economical and environmental reasons, to reuse breathing systems within 24 hours is recommended as the patient safety is not reduced.

Keywords: Bacterial contamination, Heat and moisture exchanger filter, Corrugated tubes, Reusing

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It becomes more common for corrugated tubes or breathing systems to be reused for multiple patients[1-4], particularly in Thailand, while a heat and moisture exchanger filter [HMEF] is being single used at the Y-piece of breathing systems. This HMEF is the accepted device to prevent bacterial and viral transmitting to the patient respiratory system during general anesthesia[5,6]. At Phramongkutklao Hospital, the corrugated tubes were reused within 24 hours by changing the elbow joint (Figure 1) and replacing the HMEF at the nearest position of corrugated tubes to the patient (Figure 2), for each case. Studies found that placing the HMEF at the nearest position of breathing systems to the patient affected the heat, inspiratory gas humidification, and prevented microorganisms contamination[5,7]. However, sharing corrugated tubes could be the origin of the bacterial contamination and cross infection, particularly in long-term use. In the present study, the bacterial contamination and nosocomial pneumonia were evaluated at different schedules, from 24 to 168 hours, while the corrugate tubes were shared.

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Materials and Methods

After the Institutional Review Board approval, the present experimental observational study between December 2011 and September 2012 was performed with 30 corrugated tubes in each group. When the corrugated tubes were reused, the HMEF was discarded after every use. Each new patient received both a new elbow joint and a new HMEF, which were put at the nearest position of corrugated tubes to the patient (Figure 1). In the 48, 72, 96, 120, 144, and 168 hours-group, a new HMEF at site 1 and 3 (Figure 2) were replaced every day. Microbiological samples were obtained by swabbing at Y-piece

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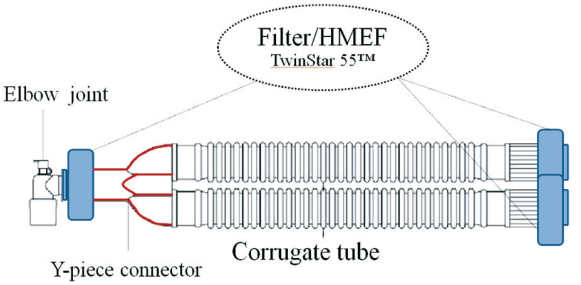

Figure 1. The figure shows breathing systems which consist of elbow joint, HMEF (blue), Y-piece connector (red), and corrugate tubes.

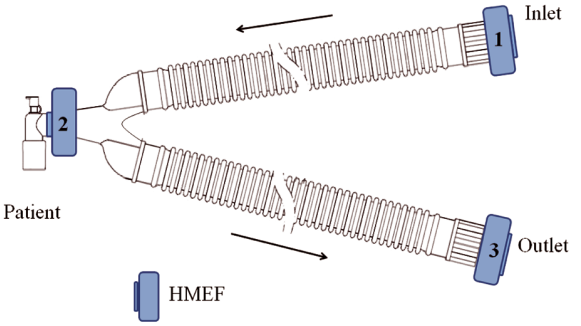

Figure 2. The figure shows sites for placing heat and moisture exchanger filter [HMEF]: 1) gas inlet, 2) Y-piece connector, and 3) gas outlet.

connector. Additionally, the washed normal saline from corrugated tubes were sent for bacterial cultured for three different agar plates (Figure 3). Swabbing at Y-piece connector was done every day, depending on the group, as shown in Table 1. The corrugated tubes

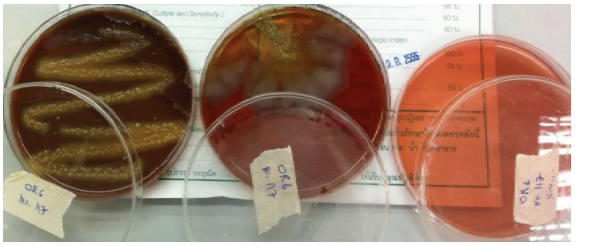

Figure 3. The figure shows 3 agar plates (from left to right; chocolate agar, blood agar, MacConkey agar).

were changed according to different time schedules at 24, 48, 72, 96, 120, 144, and 168 hours. Additionally, the corrugated tubes were sent to the clinical pathology department for bacterial culture. Regarding the washing method, injected 50 cc of 0.9% sterile normal saline into corrugated tubes, then shaking in two different directions, left and right, for 30 seconds, then up and down for next 30 seconds. The washed normal saline was poured and inoculated on three different agar plates. Finally, it was incubated in agar plates for three days then observed for bacterial colony every consecutive day. In addition, during the preoperative and post-operative period, patients were evaluated for ventilator associated pneumonia [VAP] parameters every day until discharge. VAP parameters including fever, dyspnea, respiratory secretion required suction, worsen gas exchange, new or progress infiltration on CXR, leukopenia, and leukocytosis.

Statistical analysis

Statistical analysis was carried out using Stata

Table 1. Demographic data of 7 groups

	Group 1 24 hours (n = 61)	Group 2 48 hours (n = 64)	Group 3 72 hours (n = 101)	Group 4 96 hours (n = 108)	Group 5 120 hours (n = 147)	Group 6 144 hours (n = 154)	Group 7 168 hours (n = 167)	*p*-value
Age	54.19±18.87	50.49±20.43	54.42±19.02	52.38±18.23	52.48±18.89	51.18±19.61	48.90±17.12	0.260
Male:female	33:28	31:32	41:60	60:48	74:73	72:82	80:87	0.442
BMI	22.67±4.27	24.35±5.42	23.37±5.11	24.47±4.32	24.36±5.65	23.32±4.75	24.14±5.31	0.120
ASA physical status								0.792
Class 1	19	28	41	47	64	65	82	
Class 2	24	24	40	41	57	55	57	
Class 3	18	11	20	20	26	34	28	
Smoking								0.473
No smoking	51	52	88	91	132	138	148	
Current smoking	5	8	8	10	11	7	15	
Ex-smoker	5	3	5	7	4	9	4	
No underlying disease:DM, HT, DLP, CKD	24:37	32:31	50:51	53:55	76:71	72:82	94:73	0.312
Intubation:extubation	8:53	6:57	17:84	14:94	20:127	31:123	22:145	0.406

BMI = body mass index; ASA = American Society of Anesthesiologists; DM = diabetes mellitus; HT = hypertension; DLP = dyslipidemia; CKD = chronic kidney disease

Statistical Software, version 12 (StataCorp, College Station, TX, USA), Chi-square test and McNemar's test. Significance was set up at less than 0.05.

Results

These were no statistical significant differences in demographic data between groups (Table 1) and sites of operations (Table 2). There were nine specialties in surgery such as eye, neck, vascular, neurosurgery, thoracic, colorectal, urologic, gynecologic, and general surgery. There were seven groups of samples that were classified along the duration of collection. Each group contained 30 corrugated tubes. From the total of 210 corrugated tubes, 42 were excluded because bacterial contamination was accessible. As a result, 168 corrugated tubes comprised of 891 microbiological samples from the corrugated tubes were tested for bacterial contamination. Seven microorganisms were found as shown in Table 3: *Micrococcus* spp., Coagulase-negative *Staphylococcus* [CoNS], *Pseudomonas* spp., *Bacillus* spp., *Corynebacterium* spp., *Providencia stuartii*, and *Pseudomonas paucimobilis* were found in the groups that reused breathing systems for more than 24 hours. The contamination rate was 0% of all cases from breathing systems that were changed daily. No statistically significant different trends were observed across the seven different changing intervals. When breathing systems were reused for more than 24 hours, the contamination rate increased from 12% in 48 hours group to 36% in 168 hours group, respectively (Figure 4). The Chi-square test and McNemar's test revealed no statistical significant difference among each group regarding the bacterial contamination (p<0.001). Regarding to ventilator associated pneumonia [VAP], parameters were evaluated by Chi-square test and McNemar's test. There was no statistical significant difference among each group according to transmission of nosocomial pneumonia (p<0.001) (Table 4).

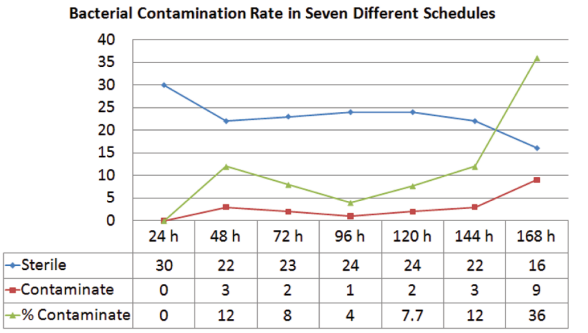

Figure 4. Graph illustrates contamination rate of corrugate tubes present from 0% (24 hours) to 36% (168 hours) after extended used in 7 groups: 24, 48, 72, 96, 120, 144, and 168 hours.

Table 2. Sites of operations in each groups

Sites of surgery	Group 1 24 hours (n = 61)	Group 2 48 hours (n = 64)	Group 3 72 hours (n = 101)	Group 4 96 hours (n = 108)	Group 5 120 hours (n = 147)	Group 6 144 hours (n = 154)	Group 7 168 hours (n = 167)	*p*-value
Head	9	15	19	21	26	19	14	0.024
Neck	3	4	5	5	6	3	10	0.812
Chest	8	4	8	4	12	14	15	0.373
Upper abdomen	19	16	17	11	28	26	32	0.022
Lower abdomen	13	17	41	54	65	84	80	0.406
Upper extremities	2	6	3	5	8	2	7	0.131
Lower extremities	7	2	8	8	6	6	9	0.277

Table 3. Type of microorganisms culture positive in each groups

Type of microorganisms	Group 1 24 hours (n = 61)	Group 2 48 hours (n = 64)	Group 3 72 hours (n = 101)	Group 4 96 hours (n = 108)	Group 5 120 hours (n = 147)	Group 6 144 hours (n = 154)	Group 7 168 hours (n = 167)
Micrococcus spp.	0	2	0	0	0	0	0
Coagulase-negative *staphylococcus*	0	1	0	0	1	1	3
Pseudomonas spp.	0	0	0	1	1	1	2
Bacillus spp.	0	0	2	0	0	1	1
Corynebacterium spp.	0	0	0	0	0	0	1
Providencia stuartii	0	0	0	0	0	0	1
Psuedomonas paucimobilis	0	0	0	0	0	0	1

Table 4. Positive in ventilator associated pneumonia [VAP] parameters in each group

VAP parameters	Group 1 24 hours (n = 61)	Group 2 48 hours (n = 64)	Group 3 72 hours (n = 101)	Group 4 96 hours (n = 108)	Group 5 120 hours (n = 147)	Group 6 144 hours (n = 154)	Group 7 168 hours (n = 167)	*p*-value
Fever	0	1	6	3	3	0	3	0.045
Dyspnea	0	0	0	1	0	0	5	0.017
Respiratory secretion	0	8	10	10	20	13	17	0.112
Required suction	0	2	1	1	4	1	3	0.553
Worse gas exchange	0	0	0	0	0	1	1	0.806
New or progress infiltration on CXR	0	0	0	0	0	0	4	0.018
Leukopenia	3	0	0	0	1	2	0	0.007
Leukocytosis	13	12	18	11	24	18	26	0.375

CXR = chest X-ray

Discussion

General anesthesia is typically obtained by an intravenous sedation-inducing agent injection within a short time with inhaled agent including a gaseous mixture of Oxygen and a volatile agent to maintain unconscious state. The essential requirement is a breathing system. This breathing system must deliver the intended inspired gaseous mixture from the anesthetic machine to the patient's alveoli. In addition, it must efficiently organize the exhaled waste gases. Generally, bacterial infection is a concern when sharing the breathing systems. Practically, there is no bacterial contamination found in short-term clinical usage of the breathing system. In addition, there is no association between the changing interval of breathing systems and the respiratory infection rate. The reuse of anesthetic breathing system with a new filter for each patient is a common practice in several hospitals particularly in developing country[1,3,4]. Additionally, no increase in the incidence of cross-infection between patients was found[4]. The reuse of anesthetic breathing systems will decrease the hospital cost and medical waste[1]. Several detected microorganisms in the present study were facultative pathogenic bacteria (Table 3). The *Micrococcus* spp., CoNS, *Pseudomonas* spp., *Bacillus* spp. and *Corynebacterium* spp. are related to respiratory tract infection, particularly in the immunosuppressive patients[8,9]. *P. stuartii* and *P. paucimobilis* are usually found as a contamination from sterile fluid, water, urine, and uncommon cause in nosocomial infection[10,11]. CoNS is also commonly found as skin flora and considered primarily non-pathogenic. Because these bacteria are considered as colonizers of the human skin flora[12], this could be an explanation for findings that bacterial contamination on the breathing systems. *Pseudomonas* spp. has been considered as nosocomial pathogens. It was colonizing and found frequently in hospitalized patients. It has been familiar as a crucial species causing pneumonia or nosocomial infections. It is involved in a wide range of serious infections including bacteremia, urinary tract infections, pulmonary infections, and meningitis[13-15]. *Bacillus* spp. such as *B. cereus*, *B. subtilis*, and *B. licheniformis* are periodically associated with bacteremia/septicemia, endocarditis, meningitis, and infections of wounds, the ears, eyes, respiratory tract, urinary tract, and gastrointestinal tract[16]. *B. cereus* causes food poisoning syndromes. *Micrococcus* spp. and *Corynebacterium* spp. are found commonly on skin contaminants[17] but is rarely the proven cause of infection except on the immunocompromised patients. As a result, this would emphasize our hypothesis in the present study that the risk of developing a respiratory tract infection from the anesthetic breathing system will be determined by the bacterial load[18] and the host defense mechanisms. In addition to contamination of hands, hand hygiene is also very important. Hygiene-related factors and the distribution of Methicillin-resistant *Staphylococcus aureus* [MRSA] including inadequate hand hygiene and disinfection and/or sterilization of medical instruments and surfaces may also be assumed to be causative of clonal CoNS spread[19-21]. This could be a part that will relate to the contamination on the breathing systems seen in the present study. From our results, we speculate that the longer the breathing systems were reused, the more it would be contaminated, particularly with pathogens. This is because we found one or more types of microorganisms cultured positive. There was no correlation between detected microorganisms in the breathing system and VAP parameters. Our study supported the results reported by other studies

suggesting that the same breathing systems could be used at least 24 hours in association with the use of new HMEF and elbow joint for every patient[1,3,4]. Breathing systems could be reused after proper use, surface cleaning, and decontamination. The filter is also very crucial. It will prevent contamination from the circuit to the patient and vice versa. Scott stated that CoNS can pass across moist breathing system filter[22]. Therefore, there could be cross-contamination when reusing a breathing system that had used a moist or wet HMEF. Discarding breathing system when HMEF is wet or contaminated with secretion or blood is the safe procedure[18]. For economical and environmental reasons, reusing a breathing system is recommended[1], as patient safety is not jeopardized. As the breathing systems are vulnerable to colonization and possible cross-contamination, every working process must be evaluated regularly to eliminate any accumulation of pathogens. In the present study, there was an inconclusive data regarding the 12% of contamination rate found on the 48-hours group, which was higher than the 8% and 4% of contamination rate in the 72-hours group and the 96-hours group, respectively. Actually, in the longer time group, there should have been a higher contamination rate rather than shorter time group, but the results were inversed in the early phase as shown in Figure 4. Further investigation is needed to confirm the safety of long-term use or reuse of the breathing systems. It is assumed in the U.S. that patients could be harmed by reusing single use filters and breathing systems multiple times. However, within 24 hours of reusing breathing system or sharing with single use HMEF is safe, because there is no evidence of serious bacterial contamination in the breathing system.

Conclusion

The long-term use and sharing of corrugated tubes during 24 hours with single use HMEF at the Y-piece of breathing system did not increase significant risk of bacterial contamination and infection. However, a HMEF is very important to prevent the contamination from the patient to the circuit and vice versa.

What is already known on this topic?

The practice of sharing breathing system is still done, however, there is no definite protocol to follow. Bacterial infection and contamination are very crucial. Patient safety is paramount. Therefore, the reuse of the medical devices must follow the institute protocol to prevent serious morbidity.

What this study adds?

The present study revealed that the safety duration for reusing the breathing systems is 24 hours. Long-term use of a breathing system without concern about bacterial contamination is prohibited and threaten serious nosocomial infection. Even though there is no data regarding the economical and environmental report in the present study, the suggestion from the present study with 24-hour-reusing only will enhance the sufficient economical policy, particularly for sustainable development.

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Potential conflicts of interest

The authors declare no conflict of interest.

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